



*Spanish Council for Scientific Research,
Ministry of Science and Innovation*

CLUAS[®]: A software for managing remotely sensed imagery of orchard plantations for precision agriculture

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CLUAS® : Software for Managing Remote Sensed Imagery for Precision Agriculture (Clustering Assessment, CLUAS)

INTRODUCTION:

- Using **very-high spatial resolution** remote sensed imagery (Airborne, Ikonos, QuickBird, WorldView) in **Precision Agriculture**: Discrimination of/within orchard plantations.
- **ENVI+IDL®**: Software to manage and analyse remote sensed imagery.
- **CLUAS®** (Clustering Assessment Software): ENVI's **add-on**.

OBJECTIVE of CLUAS:

- To automatically assess agronomic and environmental characteristics of fruit orchards and forests from remote sensed imagery.
- 1) Tree by tree; 2) Subplot by subplot; 3) Whole tree-orchard.

References:

- García-Torres, L., et al. **Registration of the Intellectual Property**, Seville, Spain, nº 200699900440900.
- García-Torres, L., et al. **Office for Patents and Trademarks**, application no. 200700256, Madrid, and PCT ES2008/ 070013, EU.
- García-Torres, L., et al. **2008**. Automatic assessment of agro-environment indicators from remotely sensed images of tree orchards and its evaluation using olive plantation. **Computers and Electronic in Agriculture**, 61, 179-191.

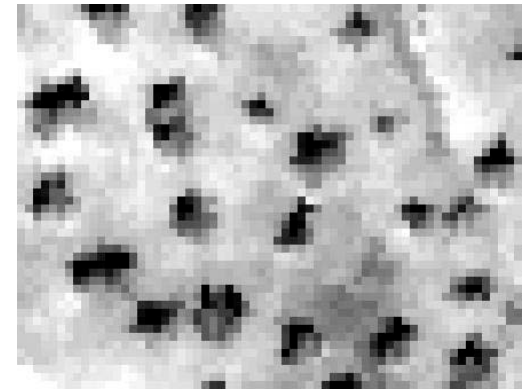
CLUAS® : Software for Managing Remote Sensed Imagery for Precision Agriculture (Clustering Assessment, CLUAS)

AIM of this presentation:

- To describe the operational procedure of CLUAS® and illustrate examples of the information provided for citrus orchards and Mediterranean forest.



Partial view of citrus tree plantation,
QB Panchromatic image



Partial view of Mediterranean Forest
(*Quercus* spp), QB Panchromatic image

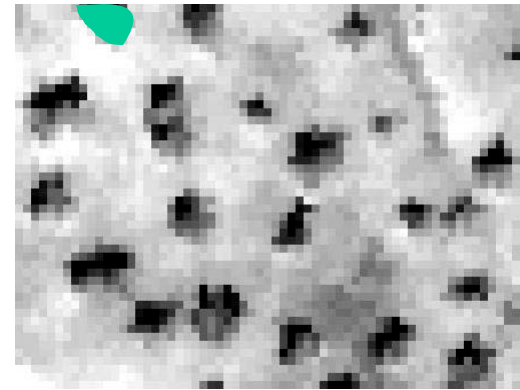
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QB Panchromatic image

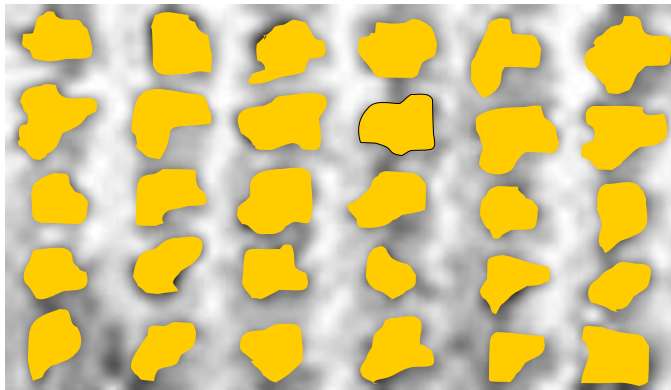


Partial view of Mediterranean Forest
(*Quercus* spp), QB Panchromatic image

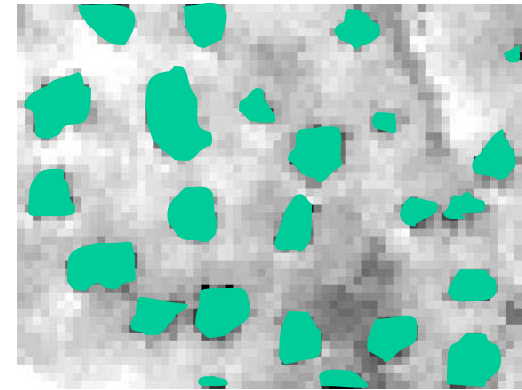
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QB Panchromatic image

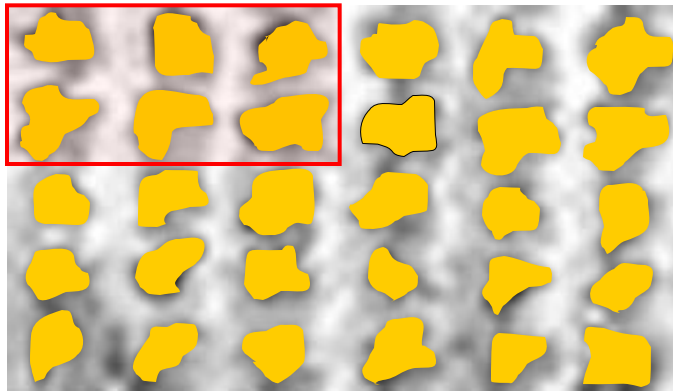


Partial view of Mediterranean Forest
(*Quercus* spp), QB Panchromatic image

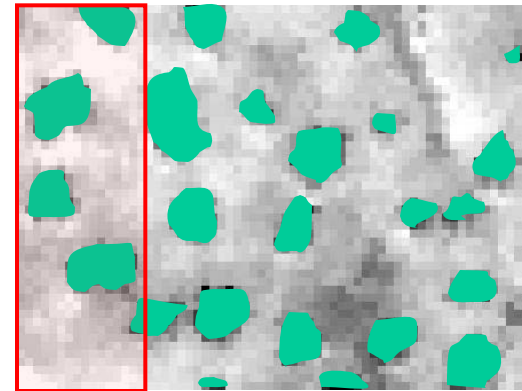
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Partial view of citrus tree plantation,
QB Panchromatic image

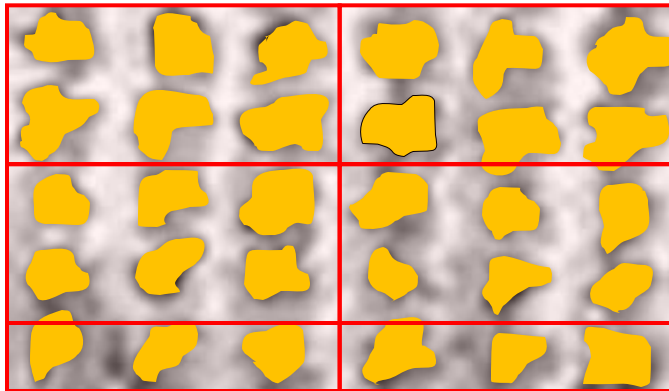


Partial view of Mediterranean Forest
(*Quercus* spp), QB Panchromatic image

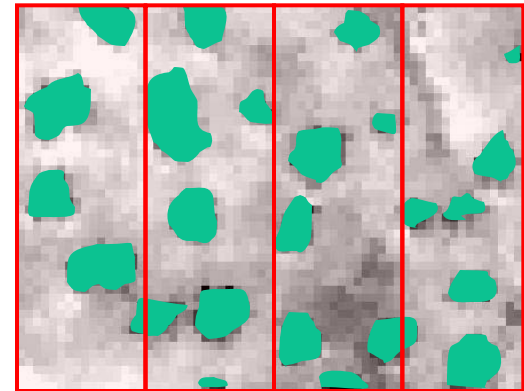
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Partial view of citrus tree plantation,
QB Panchromatic image

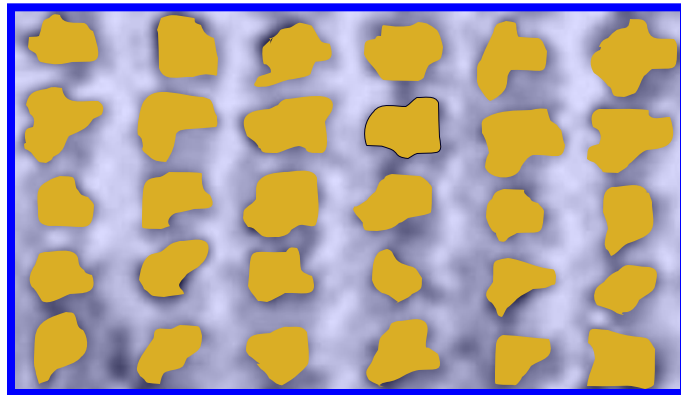


Partial view of Mediterranean Forest
(*Quercus* spp), QB Panchromatic image

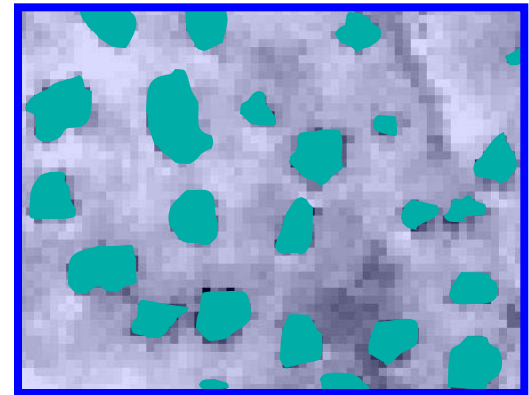
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Partial view of citrus tree plantation,
QB Panchromatic image



Partial view of Mediterranean Forest
(*Quercus* spp), QB Panchromatic image

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CLUAS® Phases:

1. **Image Pre-Processing:** field or orchard selection → Tree discrimination or classification → Definition of the Digital Value Range.

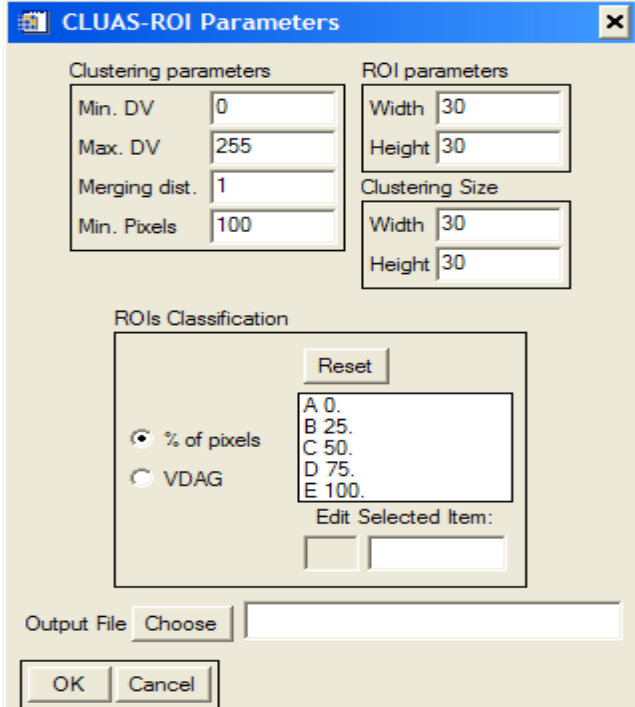
2. **CLUAS Implementation:** ENVI → Basic tools menu → Clustering Assessment add-on.
Clustering parameters: Digital Value Range (Min, Max), Merging distance, Pixel Number.

Clustering size: Width, Height.

Region of Interest (ROI) parameters: Width, Height.

ROIs Classification: Generation of subplots.

3. **CLUAS outcome report:** Interpretation and analysis.



The screenshot shows the 'CLUAS-ROI Parameters' dialog box. It is divided into several sections: 'Clustering parameters' with input fields for 'Min. DV' (0), 'Max. DV' (255), 'Merging dist.' (1), and 'Min. Pixels' (100); 'ROI parameters' with 'Width' (30) and 'Height' (30); 'Clustering Size' with 'Width' (30) and 'Height' (30); and 'ROIs Classification' which includes a 'Reset' button, radio buttons for '% of pixels' (selected) and 'VDAG', a list box containing 'A 0.', 'B 25.', 'C 50.', 'D 75.', and 'E 100.', and an 'Edit Selected Item:' field. At the bottom, there is an 'Output File' section with a 'Choose' button and a text field, and 'OK' and 'Cancel' buttons.

CLUAS® Flowchart is at: Computers & Electronics in Agriculture, 2008, 61, 179-191.

Main CLUAS Interface

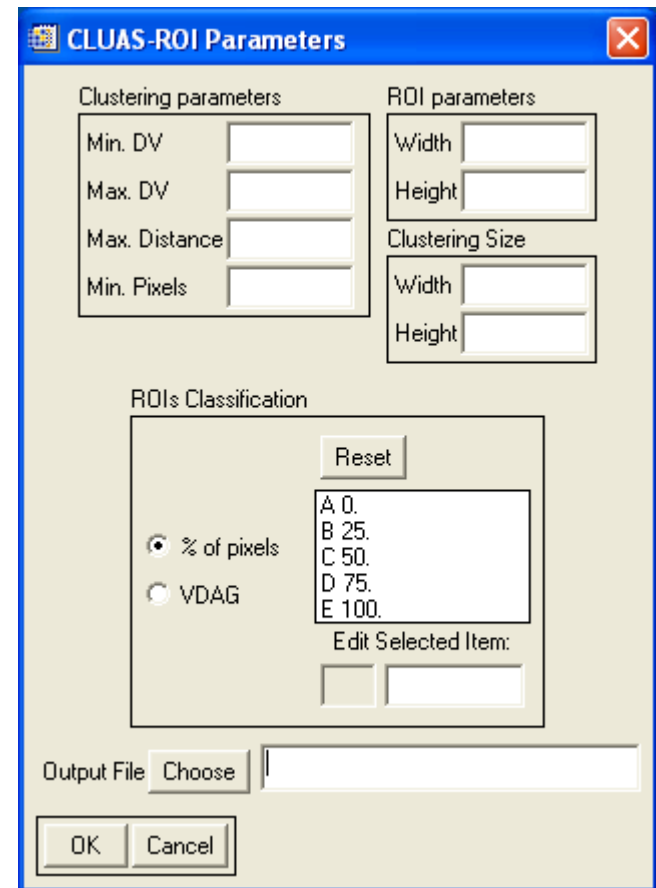
CLUAS® : Software for Managing Remote Sensed Imagery for Precision Agriculture
(Clustering Assessment, CLUAS)

CLUAS numerical process

Example 1: Assessment of *Citrus* Orchard Characteristics.



Partial view of citrus tree plantation

A screenshot of the "CLUAS-ROI Parameters" dialog box. It has a blue title bar with a close button. The dialog is divided into several sections: "Clustering parameters" with fields for "Min. DV", "Max. DV", "Max. Distance", and "Min. Pixels"; "ROI parameters" with fields for "Width" and "Height"; "Clustering Size" with fields for "Width" and "Height"; "ROI's Classification" with radio buttons for "% of pixels" (selected) and "VDAG", a "Reset" button, a list box containing "A 0.", "B 25.", "C 50.", "D 75.", and "E 100.", and an "Edit Selected Item:" section with two input fields; and an "Output File" section with a "Choose" button and a text field. At the bottom are "OK" and "Cancel" buttons.

Clustering parameters		ROI parameters	
Min. DV	<input type="text"/>	Width	<input type="text"/>
Max. DV	<input type="text"/>	Height	<input type="text"/>
Max. Distance	<input type="text"/>	Clustering Size	
Min. Pixels	<input type="text"/>	Width	<input type="text"/>
		Height	<input type="text"/>

ROI's Classification

☒ % of pixels
☐ VDAG

Reset

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File Choose

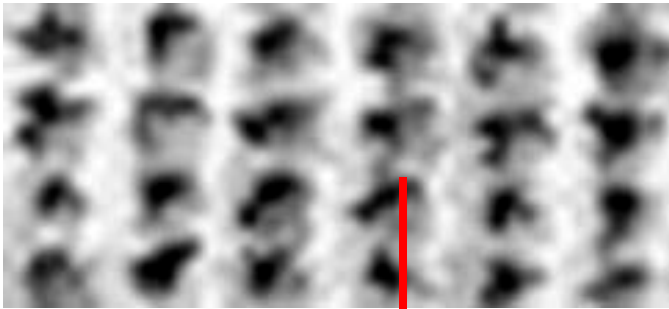
OK Cancel

Main CLUAS Interface

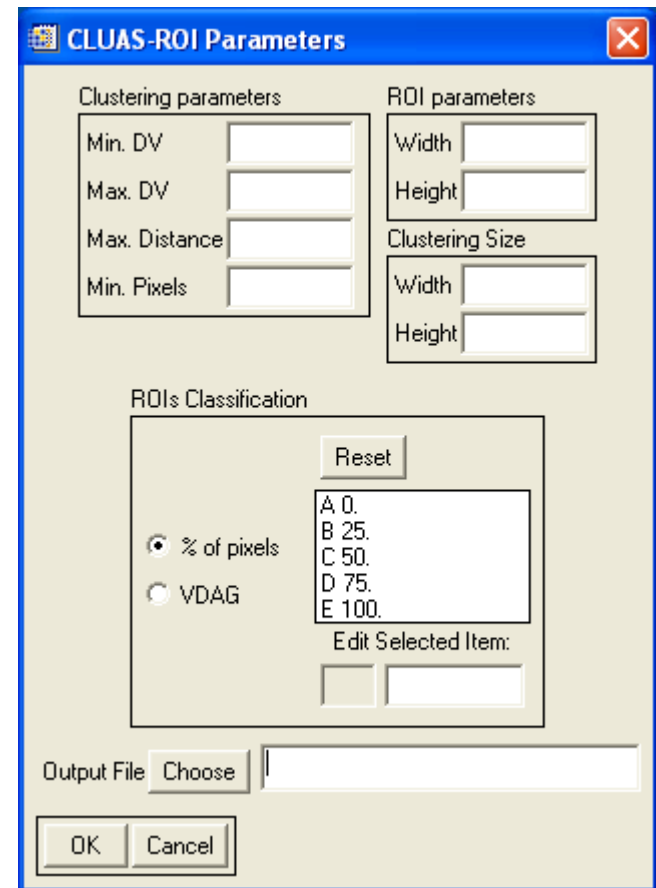
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CLUAS numerical process

Example 1: Assessment of *Citrus* Orchard Characteristics.



150	178	210	160	154	172	151	201	210	189
174	126	98	135	85	153	201	220	141	87
189	152	84	52	67	146	215	199	112	65
201	166	47	40	31	110	167	201	158	53
241	164	153	87	100	168	179	178	147	62
232	196	174	78	111	128	250	196	112	99
187	208	188	153	152	163	231	222	187	161
200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46



The dialog box is titled "CLUAS-ROI Parameters" and contains the following sections:

- Clustering parameters:**
 - Min. DV: []
 - Max. DV: []
 - Max. Distance: []
 - Min. Pixels: []
- ROI parameters:**
 - Width: []
 - Height: []
- Clustering Size:**
 - Width: []
 - Height: []
- ROI's Classification:**
 - ☒ % of pixels
 - ☐ VDAG
 - Reset button
 - List box containing: A 0, B 25, C 50, D 75, E 100.
 - Edit Selected Item: [] []
- Output File:** Choose []
- OK and Cancel buttons.

Main CLUAS Interface

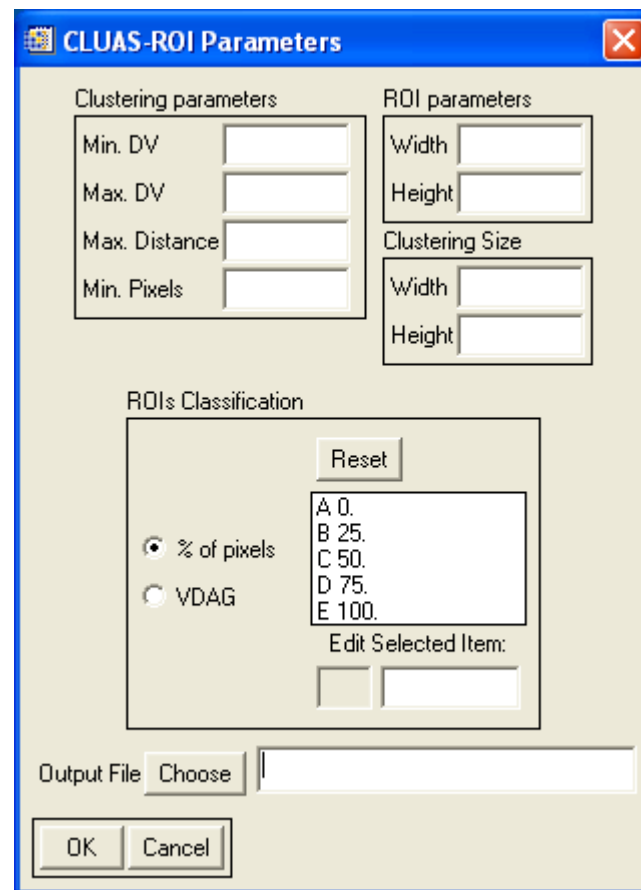
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CLUAS numerical process

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187	208	188	153	152	163	231	222	187	161
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187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46



The dialog box is titled "CLUAS-ROI Parameters" and contains the following sections:

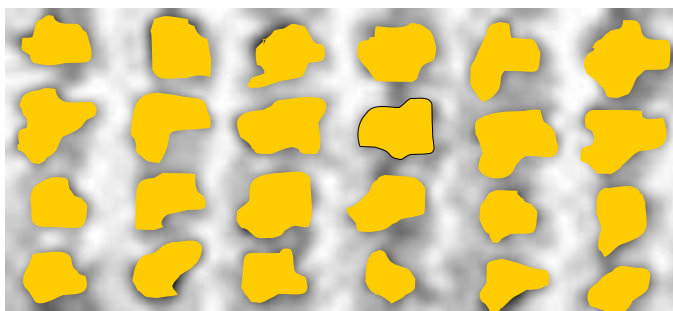
- Clustering parameters:**
 - Min. DV: []
 - Max. DV: []
 - Max. Distance: []
 - Min. Pixels: []
- ROI parameters:**
 - Width: []
 - Height: []
- Clustering Size:**
 - Width: []
 - Height: []
- ROI's Classification:**
 - ☒ % of pixels
 - ☐ VDAG
 - Reset button
 - List: A 0, B 25, C 50, D 75, E 100
 - Edit Selected Item: [] []
- Output File:** Choose []
- OK and Cancel buttons

Main CLUAS Interface

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CLUAS numerical process

Example 1: Assessment of *Citrus* Orchard Characteristics.



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187	208	188	153	152	163	231	222	187	161
200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV

Max. DV

Max. Distance

Min. Pixels

ROI parameters

Width

Height

Clustering Size

Width

Height

ROI Classification

Reset

☒ % of pixels

☐ VDAG

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File Choose

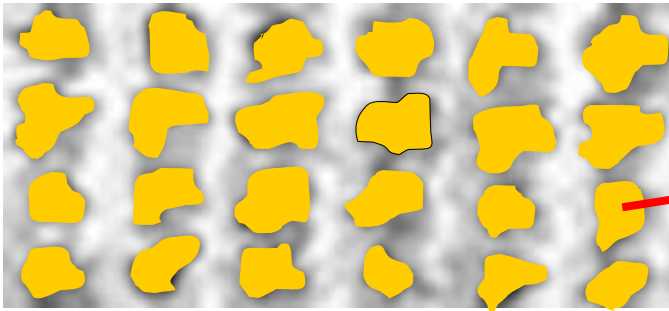
OK Cancel

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CLUAS numerical process

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200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV: 30
Max. DV: 150
Max. Distance: 1
Min. Pixels: 5

ROI parameters

Width: 10
Height: 10
Clustering Size
Width: 6
Height: 6

ROIs Classification

☒ % of pixels
☐ VDAG

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File: Choose C:\CLUAS\Citrus Results

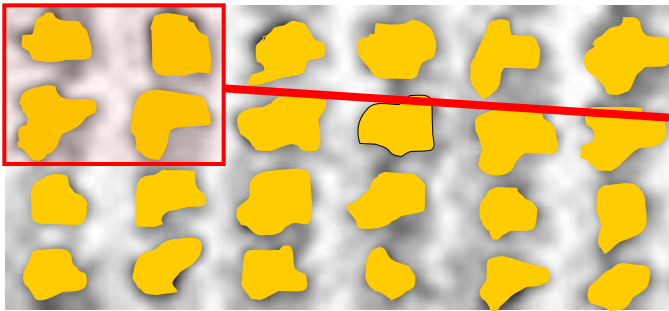
OK Cancel

Main CLUAS Interface

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CLUAS numerical process

Example 1: Assessment of *Citrus* Orchard Characteristics.



Sub-Plots

150	178	210	160	154	172	151	201	210	189
174	126	98	135	85	153	201	220	141	87
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187	208	188	153	152	163	231	222	187	161
200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV: 30
Max. DV: 150
Max. Distance: 1
Min. Pixels: 5

ROI parameters

Width: 10
Height: 10

Clustering Size

Width: 6
Height: 6

ROIs Classification

☒ % of pixels
☐ VDAG

Reset

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File: Choose C:\CLUAS\Citrus Results

OK Cancel

Main CLUAS Interface

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CLUAS numerical process

Example 1: Assessment of *Citrus* Orchard Characteristics.



150	178	210	160	154	172	151	201	210	189
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200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV: 30

Max. DV: 150

Max. Distance: 1

Min. Pixels: 5

ROI parameters

Width: 10

Height: 10

Clustering Size

Width: 6

Height: 6

ROIs Classification

Reset

☒ % of pixels

☐ VDAG

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File: Choose C:\CLUAS\Citrus Results

OK Cancel

Sub-Plot
Classification

Main CLUAS Interface

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CLUAS numerical process

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200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
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CLUAS-ROI Parameters

Clustering parameters

Min. DV: 30

Max. DV: 150

Max. Distance: 1

Min. Pixels: 5

ROI parameters

Width: 10

Height: 10

Clustering Size

Width: 6

Height: 6

ROIs Classification

Reset

☒ % of pixels

☐ VDAG

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File Choose C:\CLUAS\Citrus Results

OK Cancel

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CLUAS numerical process

Example 1: Assessment of *Citrus* Orchard Characteristics.



150	170	210	160	154	172	151	201	210	189
174	126	98	135	85	153	201	220	141	87
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Clustering parameters

Min. DV: 30
Max. DV: 150
Max. Distance: 1
Min. Pixels: 5

ROI parameters

Width: 10
Height: 10

Clustering Size

Width: 6
Height: 6

ROIs Classification

☒ % of pixels
☐ VDAG

Reset

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File: Choose C:\CLUAS\Citrus Results

OK Cancel

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CLUAS numerical process

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187	208	188	153	152	163	231	222	187	161
200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV: 30
Max. DV: 150
Max. Distance: 1
Min. Pixels: 5

ROI parameters

Width: 10
Height: 10

Clustering Size

Width: 6
Height: 6

ROIs Classification

☒ % of pixels
☐ VDAG

Reset

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File: Choose C:\CLUAS\Citrus Results

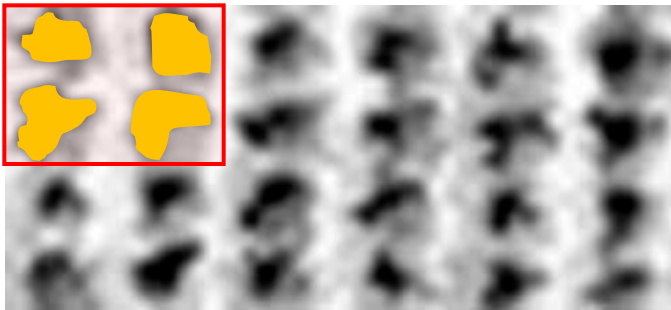
OK Cancel

Main CLUAS Interface

CLUAS® : Software for Managing Remote Sensed Imagery for Precision Agriculture (Clustering Assessment, CLUAS)

CLUAS numerical process

Example 1: Assessment of *Citrus Orchard* Characteristics.



50	170	210	160	154	172	151	201	210	189
174	126	98	135	85	153	201	220	141	87
189	152	84	52	67	146	215	199	112	65
201	166	47	40	31	110	167	201	158	53
241	164	153	87	100	168	179	178	147	62
232	196	174	78	111	128	250	196	112	99
187	208	188	153	152	163	231	222	187	161
200	163	110	172	188	85	98	188	162	141
187	98	52	45	151	200	217	172	87	99
198	153	47	78	190	188	166	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV

30

Max. DV

150

Max. Distance

1

Min. Pixels

5

ROI parameters

Width

10

Height

10

Clustering Size

Width

6

Height

6

ROIs Classification

Reset

☒ % of pixels

☐ VDAG

A 0.

B 25.

C 50.

D 75.

E 100.

Edit Selected Item:

Output File

Choose

C:\CLUAS\Citrus Results

OK

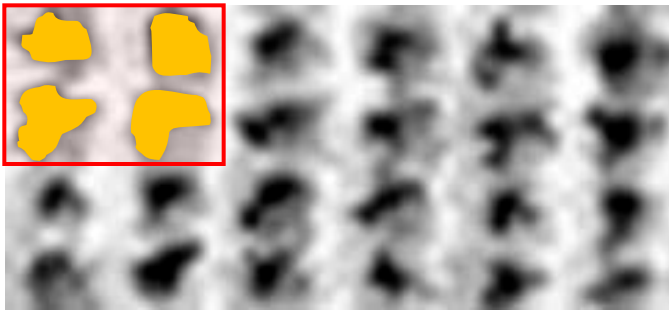
Cancel

Main CLUAS Interface

CLUAS® : Software for Managing Remote Sensed Imagery for Precision Agriculture (Clustering Assessment, CLUAS)

CLUAS numerical process

Example 1: Assessment of *Citrus Orchard* Characteristics.



0	0	0	0	0	0	0	0	0	0
0	126	98	135	85	0	0	0	141	87
0	0	84	52	67	0	0	0	112	65
0	0	47	40	31	110	0	0	0	53
0	0	0	87	100	0	0	0	147	62
0	0	0	78	111	0	0	0	112	99
0	0	0	0	0	0	0	0	0	0
0	163	110	0	0	85	98	0	0	141
0	98	52	45	0	0	0	0	87	99
0	0	47	78	0	0	0	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV: 30
Max. DV: 150
Max. Distance: 1
Min. Pixels: 5

ROI parameters

Width: 10
Height: 10

Clustering Size

Width: 6
Height: 6

ROIs Classification

☒ % of pixels
☐ VDAG

Reset

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File: Choose C:\CLUAS\Citrus Results

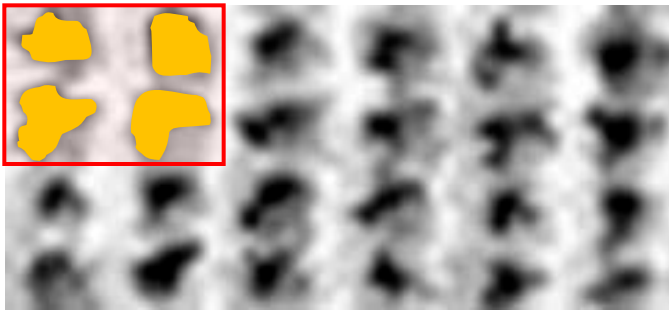
OK Cancel

Main CLUAS Interface

CLUAS® : Software for Managing Remote Sensed Imagery for Precision Agriculture (Clustering Assessment, CLUAS)

CLUAS numerical process

Example 1: Assessment of *Citrus Orchard* Characteristics.



0	0	0	0	0	0	0	0	0	0
0	126	98	135	85	0	0	0	141	87
0	0	84	52	67	0	0	0	112	65
0	0	47	40	31	110	0	0	0	53
0	0	0	87	100	0	0	0	147	62
0	0	0	78	111	0	0	0	112	99
0	0	0	0	0	0	0	0	0	0
0	163	110	0	0	85	98	0	0	141
0	98	52	45	0	0	0	0	87	99
0	0	47	78	0	0	0	142	53	46

CLUAS-ROI Parameters

Clustering parameters

Min. DV: 30
Max. DV: 150
Max. Distance: 1
Min. Pixels: 5

ROI parameters

Width: 10
Height: 10

Clustering Size

Width: 6
Height: 6

ROIs Classification

☒ % of pixels
☐ VDAG

Reset

A 0.
B 25.
C 50.
D 75.
E 100.

Edit Selected Item:

Output File: Choose C:\CLUAS\Citrus Results

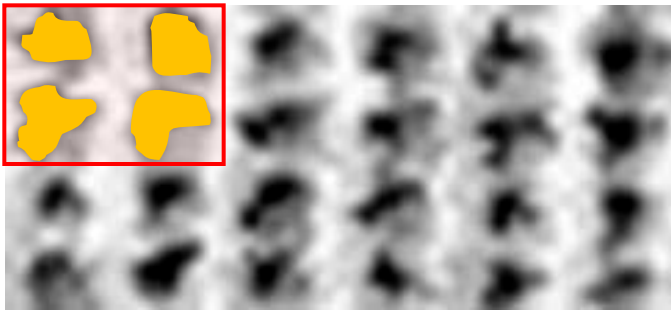
OK Cancel

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Main CLUAS Interface

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Example 1: Outcome / Assessment of **tree by tree** *Citrus* Orchard Characteristics.

Tree (AG)	X / Y	NPAG	VDAG	VDAG/NPAG	m2
Tree 1	315688 / 4186001	15	1251	83.4	7.4
Tree 2	315689 / 4185996	9	878	97.6	4.4
Tree 3	315689 / 4185991	7	593	84.7	3.5
Tree 4	315691 / 4185983	6	568	94.7	3.0
<hr/>					
NTP: 100	NTAG/NTP: 0.37 (37%)				
NTAG: 37	IVDA: 3290	VDAM: 90.1			

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References:

- García-Torres, L., et al. **Registration of the Intellectual Property**, Seville, Spain, nº 200699900440900.
- García-Torres, L., et al. **Office for Patents and Trademarks**, application no. 200700256, Madrid, and PCT ES2008/ 070013, EU.
- García-Torres, L., et al. **2008**. Automatic assessment of agro-environment indicators from remotely sensed images of tree orchards and its evaluation using olive plantation. **Computers and Electronics in Agriculture**, 61, 179-191.

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Conclusion:

- CLUAS® provides detailed agronomic information from remote sensed imagery of tree orchards/ forest, both “tree by tree” and for each small area/ micro-plot of the orchard defined.
- So, CLUAS® can contribute to setting up the basis for site specific/ precision management for plantations of trees.

